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(Parannettu mittausjärjestely)

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Tutkimussihteeri

Maksu	50 €
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Maksu perustuu kauppa- ja teollisuusministeriön antamaan asetukseen 1027/2001 Patentti- ja rekisterihallituksen maksullisista suoritteista muutoksineen.

The fee is based on the Decree with amendments of the Ministry of Trade and Industry No. 1027/2001 concerning the chargeable services of the National Board of Patents and Registration of Finland.

L3

Improved Sensing Arrangement

Parannettu mittausjärjestely

Förbättrad sensoranordning

The invention relates to an arrangement for sensing ambient conditions in electric equipment and/or for sensing biometric variables of a user. These conditions may include verification of the user, the location of the equipment and various properties of the environment. The invention is preferably applied in mobile terminals.

There is a need of providing sensors in mobile terminals in order to make the mobile terminal capable of sensing its ambient conditions. There is also a need for fingerprint sensors and other biometric sensors that can be used for authenticating the user of the terminal and for measuring other biometric variables from the user. The information can be used for context awareness applications where the ambient information and/or the user information is used e.g. for controlling the user interface profile and different settings of the mobile terminal user interface. The present invention relates to general sensing arrangements, but the prior art is next described using a fingerprint sensor first as an example.

For example, there exist several kinds of fingerprint sensors: skin impedance based sensor, thermal sensors, and optical sensors. The most practical solution for authentication of a user of small appliances, such as mobile terminals, is based on capacitive impedance measurement. The basic idea of the capacitive fingerprint sensor to measure the change of skin impedance is described in Figures 1A and 1B. An array of sensors 120 measure the skin impedance values when a finger 101 is gradually pulled over the array of sensors. The capacitance between the electrode surface and the conductive saline layer inside the skin surface varies as a function of distance to the conductive layer. The varying air gap and the dead horny cells in the surface of the skin form the capacitance 125 to the conductive layers 121, 122 forming the electrodes of the capacitive sensor.

Figure 2 shows another example including a rough equivalent circuit of the skin impedance and the impedance measurement principle. Skin has a fixed resistive tissue component 202, and a fixed resistive surface component 203. The measurement capacitance also has a fixed component 272 and a component 271 that varies according to the surface form of the finger. The capacitive fingerprint sensor

measures the varying capacitive component by applying an alternating voltage 281 to a drive electrode 222 and measuring a signal from a sensor electrode 221. The signal is amplified with a low noise amplifier 282, and the phase difference between driver and sensing electrodes is measured, 283. Interference can be suppressed with a guard electrode, which is kept in the same potential as the signal input using a buffer 285.

A fingerprint sensor and most other sensors also require a signal processing circuit, which is preferably a silicon-based integrated circuit. One solution for providing a fingerprint sensor would be to use an integrated circuit, which would serve both as capacitive measurement electrodes and as signal processing electronics. This integrated circuit would then be mounted on the surface of the appliance. However, the area needed for the capturing the capacitive image of the fingerprint is roughly in the scale of one square centimeter. This is a very large area for using a silicon integrated circuit as measurement electrodes. Furthermore, the measurement consists of hundreds of capacitive pixels that are arranged in a row or in a matrix depending on the measurement principle. A lot of wiring is needed and the measurement electrodes need to the isolated from the integrated circuits. Therefore a cost efficient method for connecting the capacitive electrodes to the signal processing silicon integrated circuit is needed.

One typical prior art solution is described in patent documents US 5887343 and US 60673268. The problem is solved by using a separate insulating planar substrate to form the measurement electrode. This substrate contains the interconnecting wiring and the vias through the substrate. The substrate is connected to the silicon integrated circuit containing the signal and data processing capabilities. However, this solution is complicated to manufacture because a large number of interconnecting wiring must be connected within a small space. Such wiring also is not very robust, which tends to make the structure to break easily in mobile use.

Another prior art solution is to create the measurement electrodes directly on top of the silicon wafer. This leads to a simple configuration of interconnecting wiring but the solution requires a large silicon surface due to the large area needed for the electrodes.

One disadvantage with the prior art solutions relates to the ergonomics of the sensor. A finger must be pressed rather heavily against the flat sensor in order to achieve sufficient contact area between the sensor and the finger. Therefore the

measurement may often fail when the finger is not pressed and slid properly along the sensor surface.

Another problem with fingerprint sensors is the easy manufacturing of an artificial finger for the user identity falsification. The prior art fingerprint sensors cannot reliably distinguish living tissue finger from an artificial plastic replica.

A further problem of the prior art solutions relates to the positioning of various sensors. In order to sense the ambient conditions the sensors need to have an interaction with the environment outside the equipment. Therefore the sensors should be located on the cover of the equipment. Sensors of this kind are generally fixed to the main printed wired board (pwb) of the equipment, and the sensors are made to extend to the surface of the equipment housing through holes in the cover. However, the surfaces of the modern equipment, such as mobile terminals, tend to have designs with three-dimensional curvature. Therefore the distance between the pwb and the cover surface varies which makes designing the sensor structure difficult. The sensors should also have determined locations on the surface of the equipment cover, and it may be difficult to design the layout of the main pwb so that the determined sensor locations are achieved. One solution to this problem is to fix the sensors to the equipment cover, but then the attachment of the sensors to the cover as well as arranging the wiring between the sensors and the main printed wired board would be difficult to realize in mass production.

The purpose of the invention is to provide a sensing arrangement with improvements related to the aforementioned disadvantages. The invented arrangement for sensors facilitates good security properties and ergonomics, as well as good suitability to serial production. Hence, the invention presents a substantial improvement to the cost efficiency and reliability of the sensors, especially in mobile applications.

A sensor arrangement comprising at least one sensor, at least one integrated signal processing circuit for the measurement of signals from the at least one sensor, and interconnecting wiring between the at least one sensor and the integrated circuit, is characterized in that the arrangement comprises a substrate, said substrate forming at least part of said interconnecting wiring and said substrate is further arranged to serve as a functional part of at least one said sensor.

The invention also concerns a mobile terminal, which comprises a sensor arrangement according to the invention.

One preferred embodiment of the invention comprises at least sensor, electrodes and the integrated circuit on a flexible substrate. Such an arrangement can be e.g. molded in the cover of a mobile station.

Further preferred embodiments of the invention are described in the dependent claims.

One idea of the invention is to provide a sensor arrangement with a substrate that forms at least part of a sensor, and preferably also serves as a substrate for other sensors. The substrate is preferably flexible so that it can be formed in a shape, which follows the shape of the device cover. The invention also describes a way to create two- or three-dimensional forms for the electrode structures that can be used to optimize the performance of the sensor. When the two- or three-dimensional surface structure is designed to follow the shape of a finger, a very small pressure is required when sliding the finger along the sensor surface. This way the use of the sensor is ergonomic and the measurement is made very reliable.

The invention also facilitates the realization of a multi sensor microsystem. The sensor elements and the measurement electronics such as ASICs can be integrated into three-dimensional module using chip-on-flex (COF) technology. The COF technology is based on the use of flexible Kapton film, for example, as the substrate for wiring and attachment of sensor and ASIC chips. The ICs and sensors can be protected using molded polymer cover on top. The flexible circuit board (e.g. Kapton film) enables the creation of 2D or 3D structures so that part of the sensors and electronics can be placed in the vicinity of the device cover.

The possibility to manufacture a curved surface in the fingerprint sensor makes it possible to integrate an optical detection of blood circulation by light absorption. This way it is possible to verify that the finger belongs to a living human being.

It is also possible to integrate other types of sensors to the sensor unit. For example, in one embodiment of the invention a light emitting diode and a light sensitive detector are placed on the opposite sides of the finger groove in order to measure light absorption through the finger. The wavelength of the light used is such that blood in a live finger causes maximal absorption signal. This way oxidized hemoglobin can be detected from the user's finger. Thus by this method also the

heartbeat rate can be monitored. This makes the usage of any artificial fingers for identification falsification very difficult. In addition, other sensors such as temperature TS and light LS sensors can be integrated within the finger groove and embedded into the fingerprint sensor package. In general, using a flexible film as a substrate gives flexibility in placing of the sensors in required locations. The flexible film can, for example, follow the shape of a device cover.

A further idea of the invention is an inductively tuned capacitive sensor that can be integrated in the cover of e.g. a mobile phone. The tuned capacitor sensor is shown to be highly sensitive for resistive losses that result from resistive material in contact with the capacitor electrodes. Based on the impedance measurement, the drop of the Q value of the tuned sensor indicates the contacting material: galvanic contact to the sensor electrodes is not needed. The inductive coupling can be done to several tuned sensors at the same or different resonance frequencies, or the coupling can be modulated from the sensor side. Use of different resonance frequencies enables the distinguishing between different sensor elements. While the inductive tuned capacitive sensors can be coupled inductively to the multi chip module containing the measurement electronics, the additional wiring in the assembly phase is not needed. This way it is possible to provide a totally sealed, waterproof device.

The fabrication process of the invention is suitable for mass production, and the invention can be applied to existing sensor measurement concepts and electronics to make the fabrication of the device more cost efficient.

Next the invention will be described in greater detail with reference to exemplary embodiments in accordance with the accompanying drawings, in which

Figure 1A illustrates using a capacitive fingerprint sensor,

Figure 1B illustrates the operating principle of a prior art capacitive fingerprint sensor,

Figure 2 illustrates a block diagram describing the measurement of skin impedance using active guarding,

Figure 3 illustrates cross section of an exemplary arrangement according to the invention, in which a flexible substrate is applied to serve as a surface for electrodes and electrical connections of the unit,

Figure 4 illustrates a cross section of an exemplary arrangement according to the invention, in which a flexible substrate is bent to serve as electrodes and a surface for electrical connections of the unit,

Figure 5 illustrates a cross section of an exemplary arrangement according to the invention, in which there are additional sensors applied on a flexible substrate,

Figure 6a illustrates a top view of an exemplary arrangement according to the invention, in which there is fingerprint sensor, optical sensor and other sensors applied on a flexible substrate,

Figure 6b illustrates a perspective view of an exemplary arrangement according to the invention, in which there are fingerprint, optical and other sensors applied on a flexible substrate,

Figure 6c illustrates a cross section view of an exemplary arrangement according to the invention, in which there is fingerprint, optical and other sensors applied on a flexible substrate,

Figure 7a illustrates a top view of an exemplary contact electrode for an arrangement according to the invention,

Figure 7b illustrates a cross section view of an exemplary contact electrode for an arrangement according to the invention,

Figure 7c illustrates an equivalent circuit for a contact measurement with the exemplary contact electrode according to Figures 7a and 7b,

Figure 8 illustrates a cross section view of an exemplary arrangement according to the invention, in which there is an inductive skin contact sensor together with optical and other sensors applied using a flexible substrate,

Figure 9a illustrates a circuit of a first embodiment for inductive contact measurement,

Figure 9b illustrates a circuit of a second embodiment for inductive contact measurement,

Figure 10	illustrates a circuit of an exemplary multi-channel inductive measurement with sensors for measuring several sensors,
Figure 11a	illustrates an exemplary circuit for passive inductive contact measurement according to the invention,
Figure 11b	illustrates an exemplary circuit for active inductive contact measurement according to the invention,
Figure 12	illustrates guarding in an exemplary arrangement according to the invention,
Figure 13a	illustrates a cross section view of a first embodiment for arranging electrodes according to the invention,
Figure 13b	illustrates a top view of a first embodiment for arranging electrodes according to the invention,
Figure 14a	illustrates a cross section view of a second embodiment for arranging electrodes according to the invention,
Figure 14b	illustrates a top view of a second embodiment for arranging electrodes according to the invention,
Figure 15a	illustrates a cross section view of a third embodiment for arranging electrodes according to the invention,
Figure 15b	illustrates a top view of a third embodiment for arranging electrodes according to the invention,
Figure 16a	illustrates a top view of a fourth embodiment for arranging electrodes according to the invention,
Figure 16b	illustrates a cross section view of a fourth embodiment for arranging electrodes according to the invention,
Figure 17	illustrates a fabrication process for a circuit with a flexible substrate.

Figures 1A, 1B and 2 were explained above in the description of prior art.

Figure 3 illustrates an embodiment of the invention enabling a two- or three-dimensional form of the electrode-finger interface. One end of a flexible printed,

wired substrate is used for electrodes 322, and other part of the substrate 363 is used for external connection. Figure 3 also shows the connections between the metallized surfaces of the flexible substrate and the ASIC 380. The wiring to the electrodes 322 and guard 330 is provided using two-sided metallization of the flex film and vias 323, 324. This arrangement including the flexible substrate, sensor and ASIC can be directly molded into a cover 368 of e.g. mobile phone.

Figure 4 illustrates an embodiment of inventive arrangement where the connection to other electronics is made by bending a flexible printed wired board (PWB) or film substrate 463 to under the unit, and attaching soldering balls 478 to the flex. In this embodiment the other end of the flex is bent above the unit in order to use the end of the flex as electrodes.. The connections 423, 424 to the ASIC 480 can be made similar to the embodiment of Figure 3. On the electrode end of the flex one metallized surface 430 serves as sensing electrode and the second metallized surface 434 of the flex serves as a guard electrode. The arrangement can be molded into plastic 468 to form an integral component.

Figure 5 illustrates an embodiment of inventive arrangement where there is a set 591 of other sensors on the flexible substrate 563 in addition to fingerprint sensor electrodes 520. The sensors may include optical sensors, a temperature sensor, a humidity sensor, a pressure sensor, an acceleration sensor, alignment sensor, biometric sensors etc. There is an aperture 592 in the flexible substrate for providing a sensing interface between outer part of the device and the sensors. The other end of the flexible substrate 563 comprises the ASIC circuit 580 and electrical connection 578 to the external circuits.

Figures 6a, 6b and 6c illustrate an exemplary arrangement according to the invention, in which there are fingerprint, optical and other sensors applied on a flexible substrate. Figure 6a shows a top view, Figure 6b shows a perspective view and Figure 6c shows a cross-section view of the arrangement. The ASIC 680 is mounted on a printed wired board 699, which may be a board used for other electronics of the device. The ASIC is connected to a flexible substrate 663, which connects the ASIC to the sensors and electrodes. The sensor substrate 668 can also be made of the flexible substrate. The substrate is of a curved form in order to provide a suitable surface for a finger 601. There are in this exemplary arrangement eight electrodes 622 provided on the flexible substrate for the fingerprint sensor. An optical pulse oximeter sensor is formed with an infrared LED 695 and a photodiode 696. Infrared pulsed light provided by the LED is measured with the photodiode

after the beam has penetrated through the finger 601. This way it is possible to verify that the finger includes blood, the concentration of which fluctuates according to the heart pulse. The arrangement also comprises a temperature sensor that can be used for measuring the ambient temperature or the temperature of the finger. The arrangement may also comprise a light sensor 698 for measuring the ambient light. This information can be used e.g. for controlling the intensity of the display of the device. The arrangement can further comprise a humidity sensor for measuring the ambient humidity.

Instead of or in addition to providing a fingerprint sensor it may be advantageous to provide one or several skin contact sensors. A skin contact sensor can be used e.g. for checking whether the device is held in hand, or whether a mobile station contacts the ear of the user (i.e. the mobile station is used for a phone conversation).

Figures 7a and 7b illustrate an example of a skin contact electrode. Figure 7a shows a top view of the electrodes and Figure 7b shows a cross section view of the electrodes and their wiring. The skin contact is determined by measuring the impedance between the center electrode 710 and the electrode 712 forming the outer ring. The electrode 711 serves as a guard ring. The guard electrode also forms a guard disc 713 below the active electrodes 710 and 712. The electrodes can be molded into plastic 714, thus e.g. forming a separate component or being integrated into a device cover.

Figure 7c illustrates an equivalent circuit for a skin contact measurement with the exemplary contact electrode according to Figures 7a and 7b. The actual skin impedance R_sk_1 is measured by applying an alternating current I_ac_in to the center and outer electrodes. Contact capacitances C_contact_1 and C_contact_2 appear in series with the skin impedance. The measured voltage in point n3 is also affected by the resistance of the electrode wires R_s, as well as by inductive component L_p, resistive component R_p and capacitive component C_p of the substrate effect.

Figure 8 illustrates a cross section view of an exemplary arrangement according to the invention, in which there is an inductive skin contact sensor together with optical and other sensors applied using a flexible substrate. The skin contact is measured by applying an alternating current to conductive electrodes 810 and 812, which can be made e.g. of conductive polymer. The electrodes are connected to ends of a planar coil 816, which receives inductive energy from another coil 815. The

coil 815 is located on a flexible substrate 863, which can be on a small distance from the device cover 814. Other sensors are installed in a sensor box 892 on the flexible substrate. There is an aperture 892 through the substrate and the device cover for providing a sensing interface between the sensors and the ambient of the device. The flexible substrate is further connected to an ASIC circuit 880, which provides the measurement electronics and circuits for processing the measured data. The flexible substrate provides wiring between the sensors and the ASIC. The ASIC and the substrate are further connected 878 to a printed wired board 899 of the device.

Figures 9a and 9b illustrate two basic principles of the inductive measurement of skin contact. In Figure 9a the circuit has fixed capacitances and thus fixed resonance frequency. The skin contact has thus an on/off switching effect to the resonance circuit. In Figure 9b the circuit has variable capacitors and low Q-value so that the resonance frequency can be changed according to the effect of the skin contact. This circuit gives more accurate information on the skin contact effect, but on the other hand the complexity and energy consumption are higher. Figures 9a and 9b show circuits where the sensor side is a passive LC resonator. However, it is also possible to use an active measurement circuit, as shown in Figure 11b.

Figure 10 illustrates an arrangement with inductive sensor coupling, which comprises circuits for measuring several sensors using different measurement frequencies. The arrangement has three sensor circuits each forming a resonance circuit; Cb1-Lb1-S1, Cb2-Lb2-S2 and Cb3-Lb3-S3. The primary resonance circuit La-Ca can be adjusted to different frequencies by controlling capacitance Ca. A Frequency sweep logics F1 controls both the resonance frequency and frequency of a self-oscillating system that comprises an amplifier G1 and a control block CN1. The frequency is swept within a frequency range that covers resonance frequencies of each sensor. With a correlator it is then possible to define which sensors are resonating on their individual resonance frequencies, or to define the exact resonance frequency for each sensor circuit.

Figure 11a illustrates an equivalent circuit for a skin contact measurement with a passive inductive arrangement. The actual skin impedance R_sk is measured by applying an alternating current to the primary coil L_15, C_15 and measuring the impedance Z. Due to energy transfer between coils a measurement current is induced to the secondary coil L_16, C_16. The secondary impedance is affected by the actual skin resistance R_sk and contact capacitances C_contact_1 and

C_contact_2 appearing at the skin-electrode contact. The value of the skin resistance R_sk is typically one kilo-ohm. When skin comes into contact with the electrodes, the effect is the same as connecting with a switch S an impedance Z_eq in parallel with the secondary coil. The value of Z_eq is determined by the skin resistance and the contact capacitances, and its value is typically e.g. 200 kilo-ohms. The change in the secondary impedance can then be detected by measuring the primary impedance Z.

Figure 11b illustrates an equivalent circuit for a skin contact measurement with an active inductive arrangement. In this arrangement there is an active measurement circuit 1145, which receives its operating power by inductive coupling from the tank circuit. The circuit 1145 measures the impedance between points 1110 and 1112, and transfers the measurement values by modulating the inductive coupling. The modulation may change the impedance measured from the detector side, or the modulation may change the frequency with which the tank circuit oscillates. In order to vary the frequency, the circuits C-L_15 and L_16 - C_16 are designed to oscillate within a wide frequency band. It is also possible to use one circuit 1145 for measuring several sensors. The measurement values from each sensor can be transferred sequentially to the detector with the modulation.

In previous Figures the idea of inductive coupling has been explained as applied to skin contact measurement. However, the inventive idea of inductive measurement is not in any way restricted to the implementations of skin contact measurement; the inductive arrangement can be used for applying energy to any type of sensors, and for measuring the sensor's output. The inventive idea of inductive measurement is not either restricted only for use with the inventive sensor arrangement including a substrate. The inductive coupling gives a possibility to provide a totally sealed cover structure without any sensor wiring between the sensors on the cover and inner electronics.

In the following some solutions are presented for providing shielding/guarding for the electrodes in an arrangement according to the invention. These examples are related to fingerprint sensors, but the solutions can also be used in e.g. skin contact measurements.

Figure 12 illustrates top and cross-section views of exemplary sensing electrodes 1222 and guard electrodes 1228 on a substrate 1263. The guard electrodes 1228 are located under the sensing electrodes 1222 with an insulating layer 1229 between the

electrodes. In this embodiment the guard electrodes have larger surface. A buffer amplifier 1285 keeps the guard electrodes in the same potential as the sensor electrodes and thus the sensor electrodes are less loaded by adjacent materials or interference.

Figures 13a and 13b illustrate a cross-section view and a top view of a first embodiment of an electrode arrangement according to the invention. In this embodiment sensing electrode s is led on a conductive layer, which is between two guard layers g. this way it is possible to achieve an efficient guarding for the sensing electrode. The drive electrodes D are led on the top conductive layer.

Figures 14a and 14b illustrate a cross-section view and a top view of a second embodiment of an electrode arrangement according to the invention. In this embodiment sensing electrode s is led on a conductive layer, which is between a guard layer g and a grounded EMC layer. The drive electrodes D are led on the top conductive layer.

Figures 15a and 15b illustrate a cross-section view and a top view of a third embodiment of an electrode arrangement according to the invention. In this embodiment sensing electrode s is led on a conductive layer, which is between two grounded EMC layers. The guard does not have layer of its own, but it led on same layers as the sensor and drive electrodes. This is possible when the guard electrode wiring and the sensing electrode wiring are perpendicular to each other.

Figures 16a and 16b illustrate a top view and a cross-section view of a fourth embodiment of an electrode arrangement according to the invention. In this embodiment the guarding and drive electrode wiring are on the top layer, and perpendicular to the sensing electrode wiring. The sensing electrode wiring is led between two grounded EMC layers, and thus a coaxial-type shielding is achieved for the sensing electrode wiring.

In order to achieve most efficient guarding, the sensing electrodes should have an individual guard, which is individually controlled by a guard amplifier. However, since the sensing electrodes are often read in a time-multiplexed manner, it could be advantageous to use one guarding amplifier and to connect it always to the guard electrode of the sensing electrode, which is currently read. A further possibility is to use moving pixel guarding.

If the guard electrode is common to all sensing electrodes, the guard electrode can be connected e.g. to ground (passive guarding), or to an average potential of the sensing electrodes. One further possibility to reduce interference is to connect the drive electrode to the hand of the user, e.g. via the device cover.

Figure 17 illustrates an exemplary process for manufacturing an arrangement according to the invention using a flexible substrate. The Figures show a cross section of the unit to be manufactured after the concerned manufacturing phase has been executed. First in phase 11 overlay is fabricated using polyimide substrates. Also interconnects patterned with copper. On phase 12 adhesive is applied and the dies are boded to the overlay. On phase 13 a plastic substrate is molded around the dies. On phase 14 vias are drilled and metallization is sputtered to form electrical connections. Finally, phase 15 includes passivation and deposition of solder balls for providing an external interface.

The invention has been explained above with reference to the aforementioned embodiments, and several industrial advantages of the invention have been demonstrated. It is clear that the invention is not only restricted to these embodiments, but comprises all possible embodiments within the spirit and scope of the inventive thought and the following patent claims. For example, the inventive idea of the sensor arrangement is not restricted to be used in mobile terminals, but it can be applied also in many other components and purposes. The invention is not either restricted to use of the mentioned materials. The inventive idea of inductive measurement can also be regarded as an independent invention to include implementations where there is no sensor arrangement with the present inventive use of substrate.

L4

Claims

1. A sensor arrangement comprising at least one sensor (322, 622, 696), at least one integrated signal processing circuit (380, 680) for the measurement of signals from the at least one sensor, and interconnecting wiring (323, 324) between the at least one sensor and the integrated circuit, **characterized** in that the arrangement comprises a substrate, said substrate forming at least part of said interconnecting wiring and said substrate is further arranged to serve as a functional part of at least one said sensor.

2. An arrangement according to claim 1, **characterized** in that said integrated circuit is attached on said substrate.

3. An arrangement according to claim 1, **characterized** in that said substrate is made of flexible film, the flexible film comprising said wiring between the at least one sensor and the integrated circuit.

4. An arrangement according to claim 1, **characterized** in that the flexible film comprises an electrode (322, 422) of at least one said sensor.

5. An arrangement according to claim 1, **characterized** in that the flexible substrate comprises wiring (363, 463, 878) for an external connection.

6. An arrangement according to claim 1, **characterized** in that said interconnecting wires are metallizations on polymer layers.

7. An arrangement according to claim 4, **characterized** in that it comprises a guard ring (827, 828) in the vicinity of the at least one sensor electrode.

8. An arrangement according to claim 7, **characterized** in that wiring of said guard ring is perpendicular to the wiring of said sensor electrode.

9. An arrangement according to claim 6 or 7, **characterized** in that the sensor comprises several sensor electrodes and a guard ring for each sensor electrode, and the guard rings are controlled individually according to potential of each sensor electrode.

10. An arrangement according to claim 6 or 7, **characterized** in that the sensor comprises several sensor electrodes that are measured sequentially, and several guard rings, wherein a guard ring of a sensor is controlled time multiplexed to the potential of the sensor for the period of measuring the sensor.

11. An arrangement according to claim 6 or 7, **characterized** in that the sensor comprises several sensor electrodes and guard rings, and all guard rings are controlled into an average potential of the sensor electrodes.

12. An arrangement according to claim 1, **characterized** in that the surface of said substrate has a curved form in at least two dimensions.

13. An arrangement according to claim 12, **characterized** in that said form approximates the form of a finger.

14. An arrangement according to claim 1, **characterized** in that it comprises a fingerprint sensor comprising at least one driver electrode and a row of sensing electrodes.

15. An arrangement according to claim 14, **characterized** in that said measurement circuit is adapted to measure successive signals while the finger moves in a perpendicular direction in relation to said row of sensing electrodes, for providing a two dimensional matrix of capacitive measurement results from the finger.

16. An arrangement according to claim 1, **characterized** in that the arrangement further comprises a infrared light source, a infrared light detector and second measurement means for measuring absorption of infrared light from the finger.

17. An arrangement according to claim 16, **characterized** in that said infrared light source and said infrared light detector are located at opposite sides of a groove designed for a finger.

18. An arrangement according to claim 1, **characterized** in that said arrangement further comprises a temperature sensor for measuring ambient temperature.

19. An arrangement according to claim 1, **characterized** in that said arrangement further comprises a humidity sensor for sensing ambient humidity.

20. An arrangement according to claim 1, **characterized** in that said arrangement further comprises a pressure sensor.

21. An arrangement according to claim 1, **characterized** in that said arrangement further comprises a skin contact sensor.

22. An arrangement according to claim 1, **characterized** in that said arrangement further comprises a sensor fixed on the substrate.

23. An arrangement according to claim 1, **characterized** in that said arrangement comprises a biometric sensor.

24. An arrangement according to claim 1, **characterized** in that said substrate comprises means for forming a sensor together with a sensor part, wherein said substrate and said sensor part are galvanically separated, and wherein said substrate and said sensor part comprise means for transferring energy and measurement information inductively between said substrate and said sensor part.

25. An arrangement according to claim 24, **characterized** in that said sensor part is a passive circuit.

26. An arrangement according to claim 24, **characterized** in that said sensor part comprises an active circuit further comprising means for measuring sensor information and means for transferring the measurement information inductively to said substrate.

27. An arrangement according to claim 24, **characterized** in that said sensor is a skin contact sensor.

28. A mobile terminal, **characterized** in that it includes a sensor arrangement according to any of the preceding claims.

29. A mobile terminal according to claim 28, **characterized** in that at least part of the sensor arrangement is encapsulated, such as molded, in the cover of the mobile terminal.

30. A mobile terminal according to claim 28, **characterized** in that the sensor arrangement comprises a flexible film substrate and the flexible film substrate is encapsulated in the cover of the mobile terminal.

L5

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(57) Abstract

The invention relates to an arrangement for sensing ambient conditions in electric equipment. These conditions may include verification of the user, the location of the equipment and various properties of the environment. The invention is preferably applied in mobile terminals. One idea of the invention is to provide a sensor arrangement with a substrate (663) that forms at least part of a sensor, and also serves as a substrate for other sensors (695-698). The substrate is preferably flexible so that it can be formed in a shape which is follows the shape of the device cover. The invention also describes a way to create two- or three-dimensional electrode structures that can be used to optimize the performance of the sensor. When the surface structure is designed to follow the shape of a finger, a very small pressure is required when sliding the finger along the sensor surface. This way the use of the sensor is ergonomic and the measurement is made very reliable.

Figure 6b

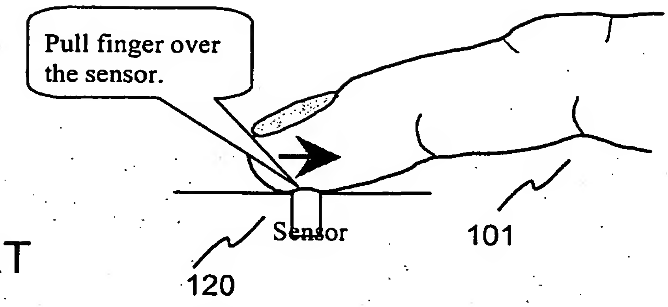

FIG. 1A
PRIOR ART

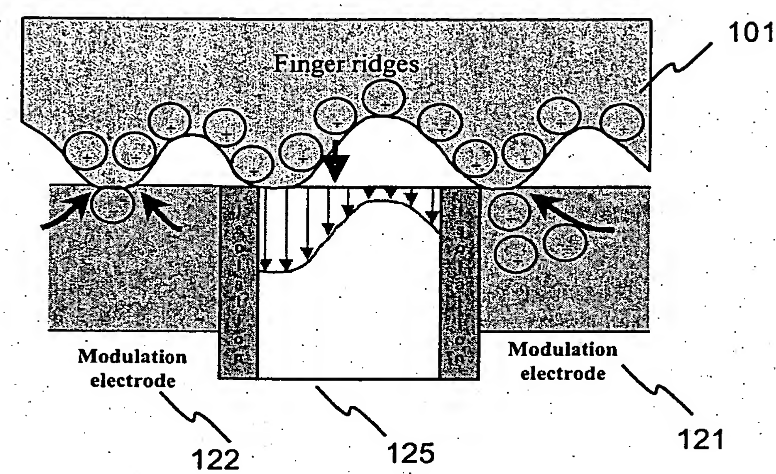

FIG. 1B
PRIOR ART

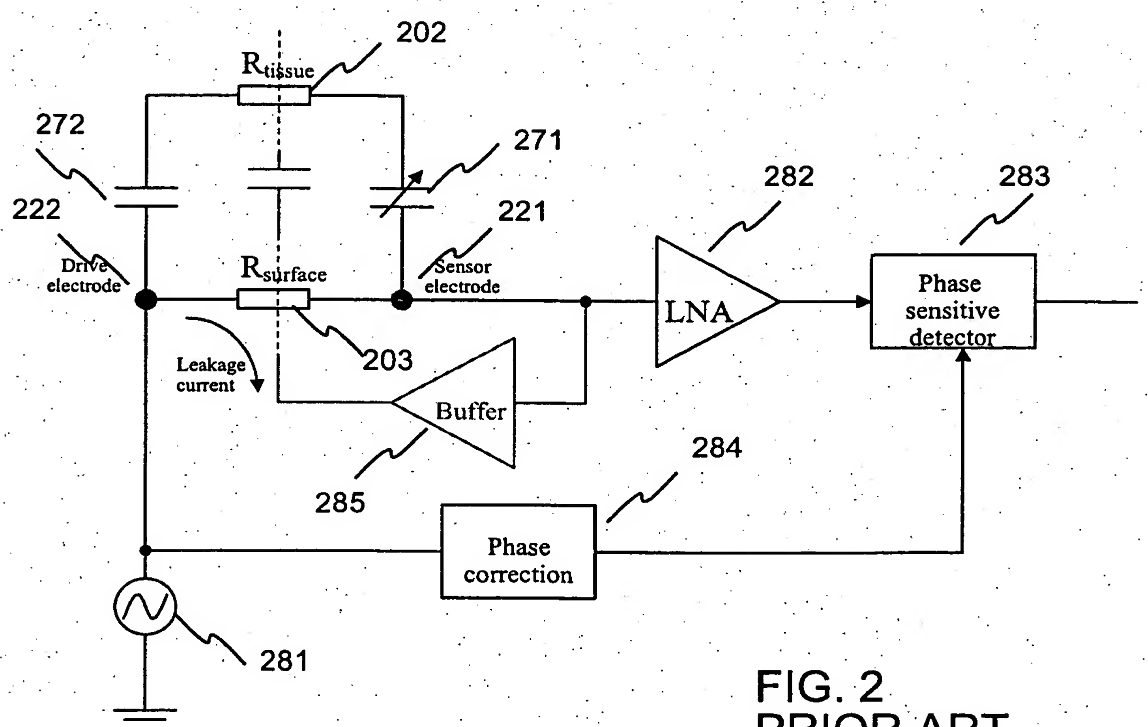

FIG. 2
PRIOR ART

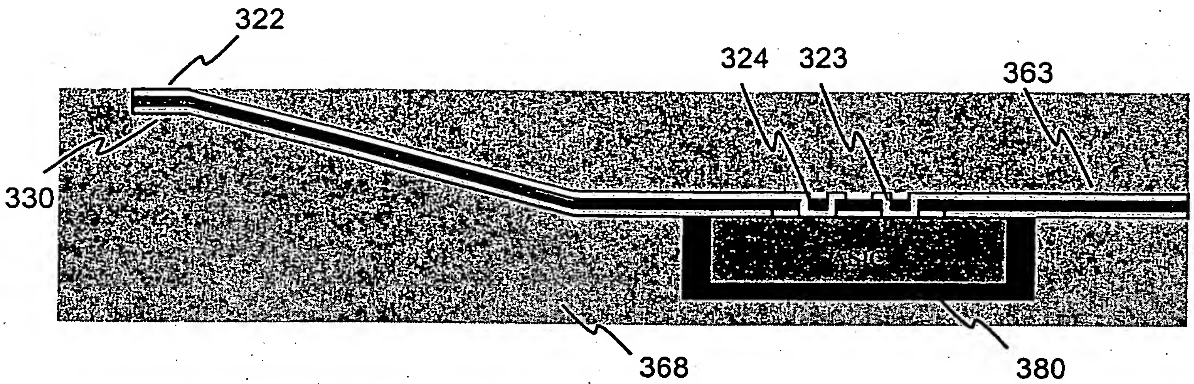

FIG. 3

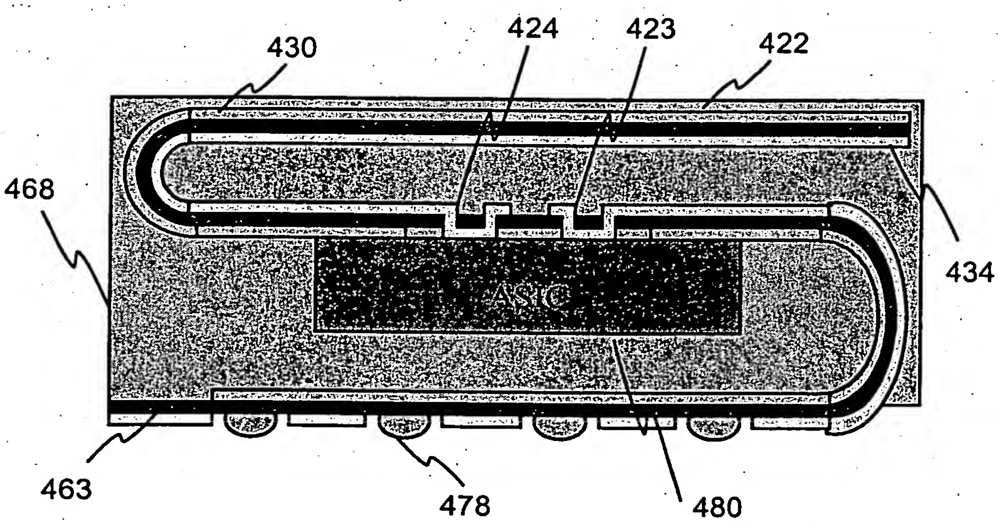

FIG. 4

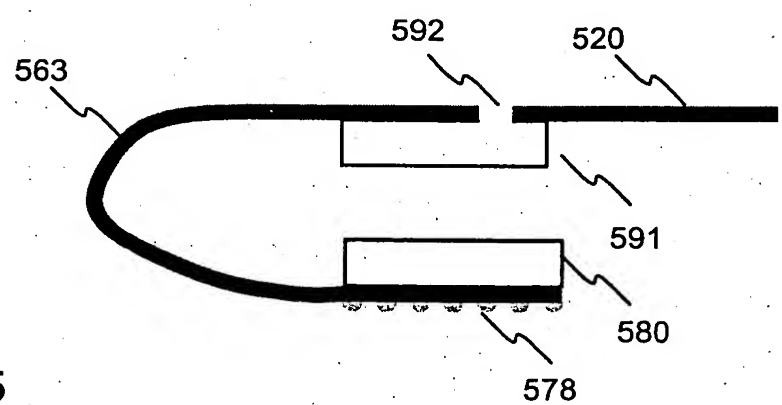

FIG. 5

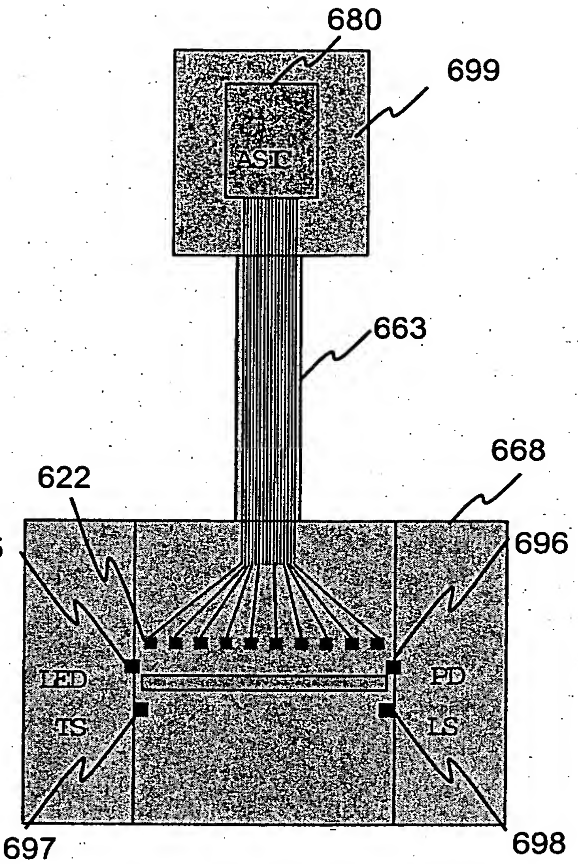

FIG. 6 a

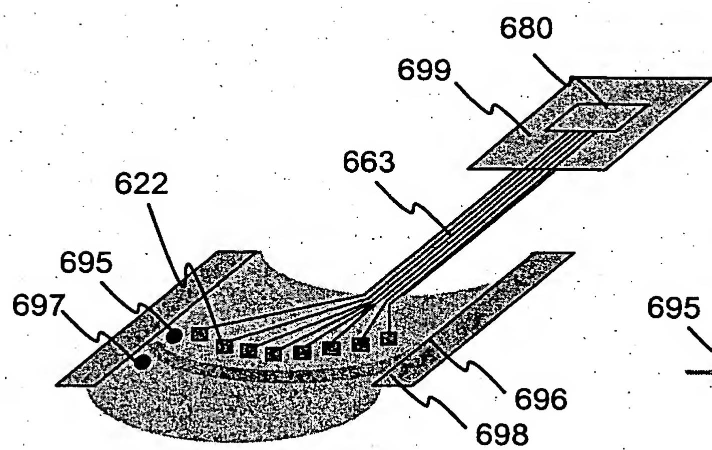

FIG. 6 b

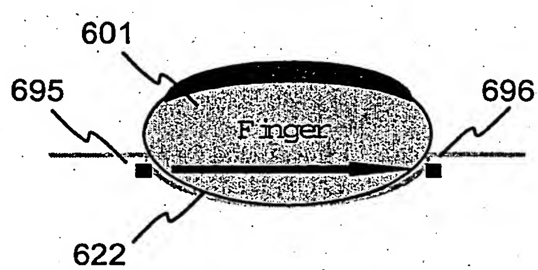

FIG. 6 c

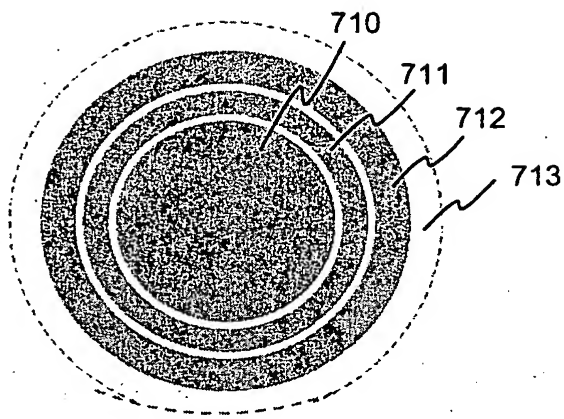

FIG. 7a

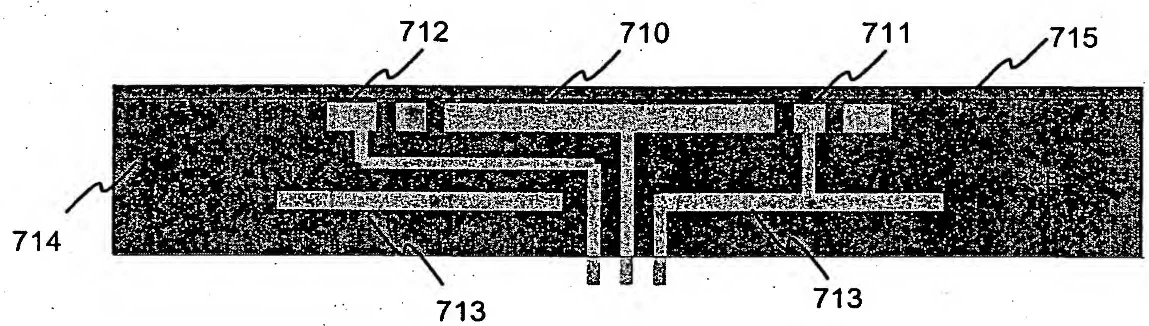

FIG. 7b

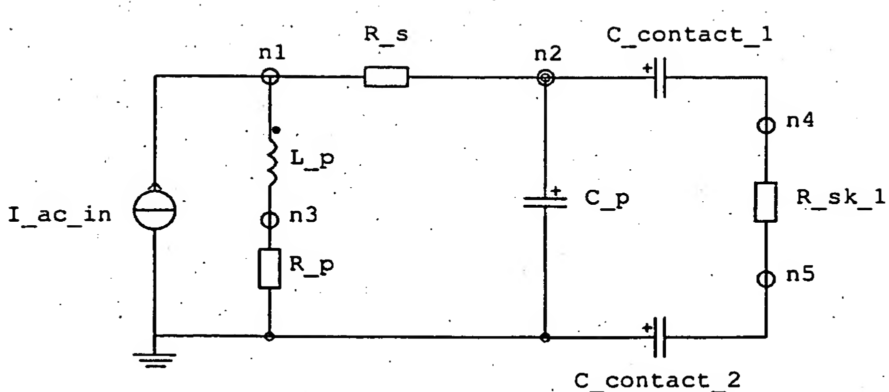

FIG. 7c

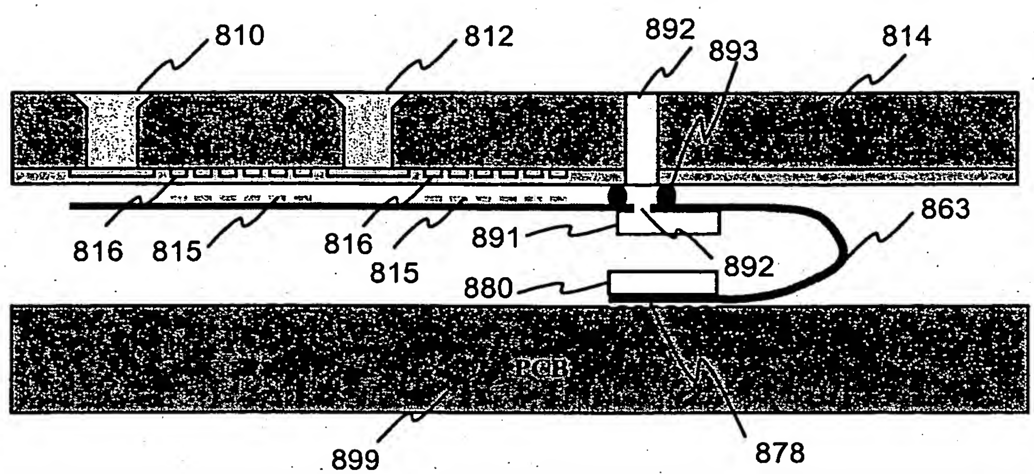
810
812
892
893
814
816
815
816
815
891
892
863
880
PCB
899
878

FIG. 8

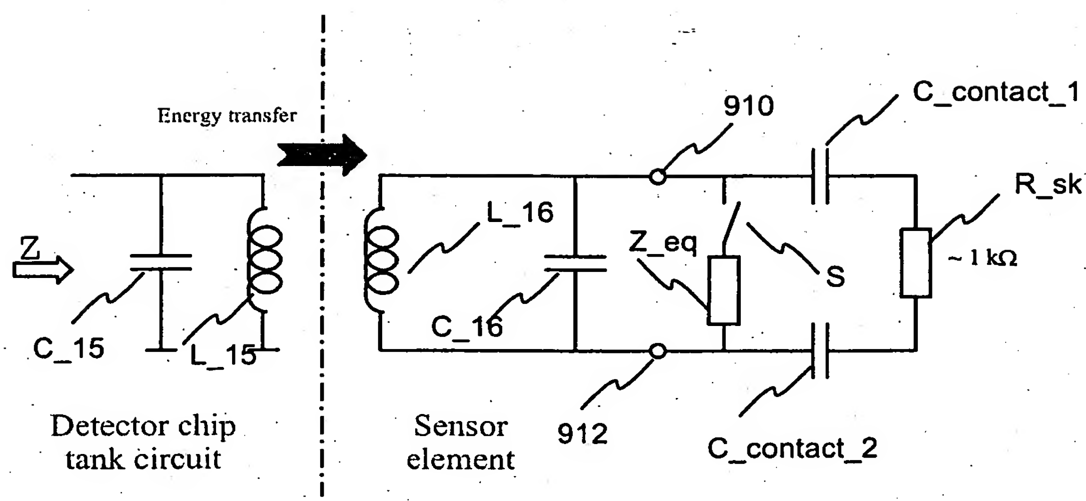
Energy transfer
Z
C_15
L_15
Detector chip
tank circuit
L_16
C_16
Sensor
element
910
912
Z_eq
S
C_contact_1
C_contact_2
R_sk
~ 1 kΩ

FIG. 9

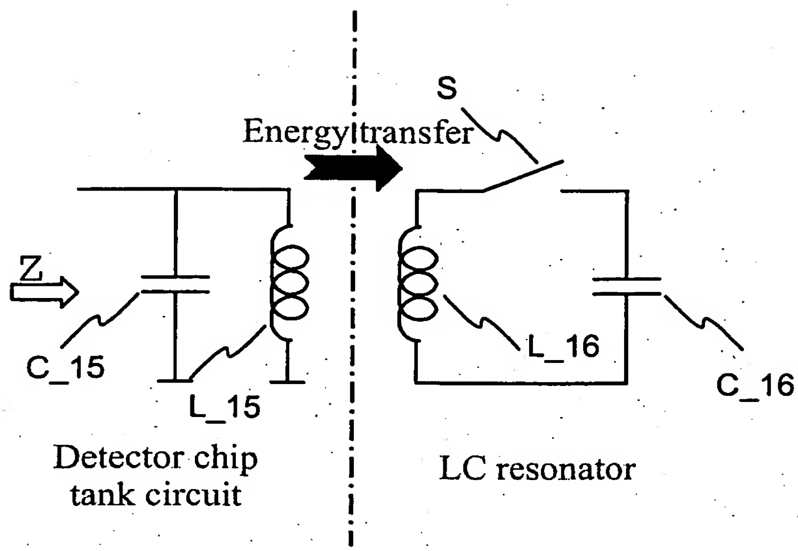

FIG. 10a

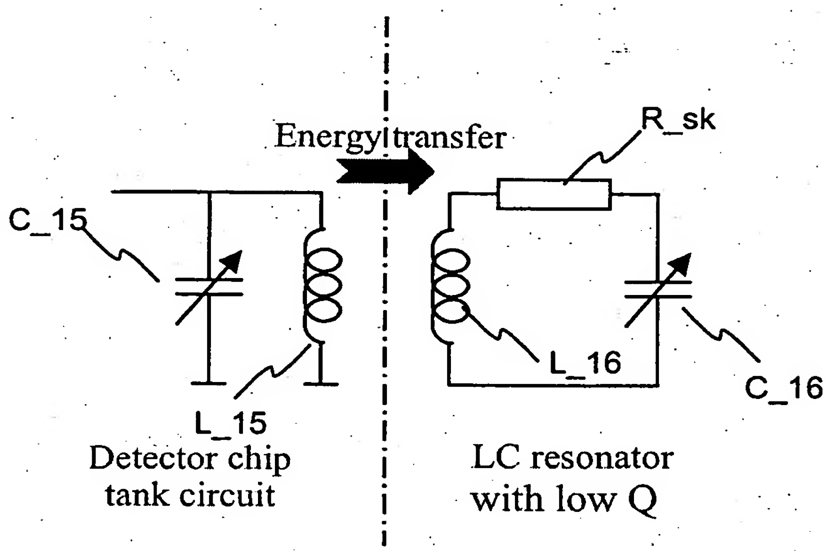

FIG. 10b

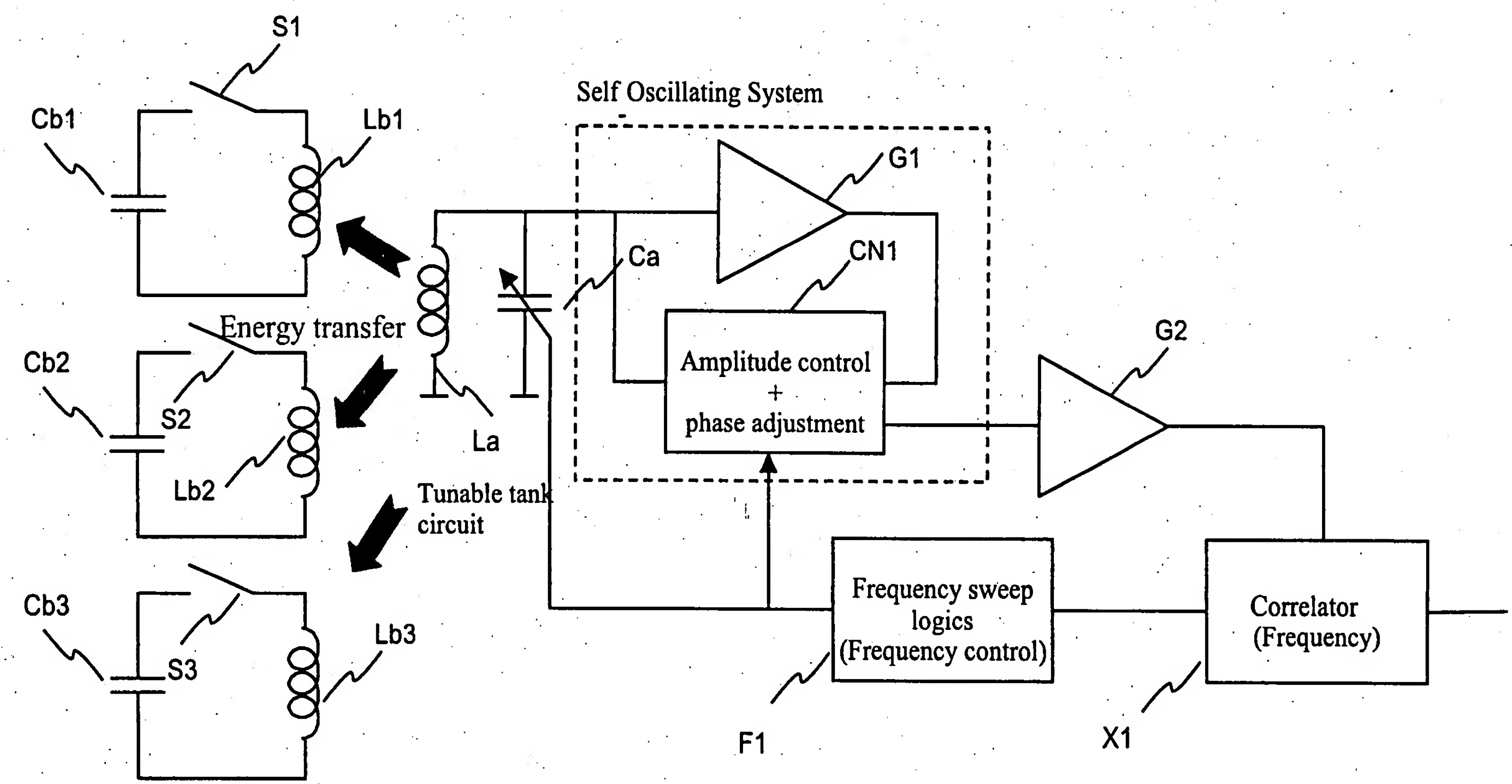
S1
Cb1
Lb1
Self Oscillating System
G1
Ca
CN1
Energy transfer
Cb2
S2
Lb2
La
Amplitude control
+
phase adjustment
G2
Tunable tank
circuit
Cb3
S3
Lb3
Frequency sweep
logics
(Frequency control)
Correlator
(Frequency)
F1
X1

FIG. 11

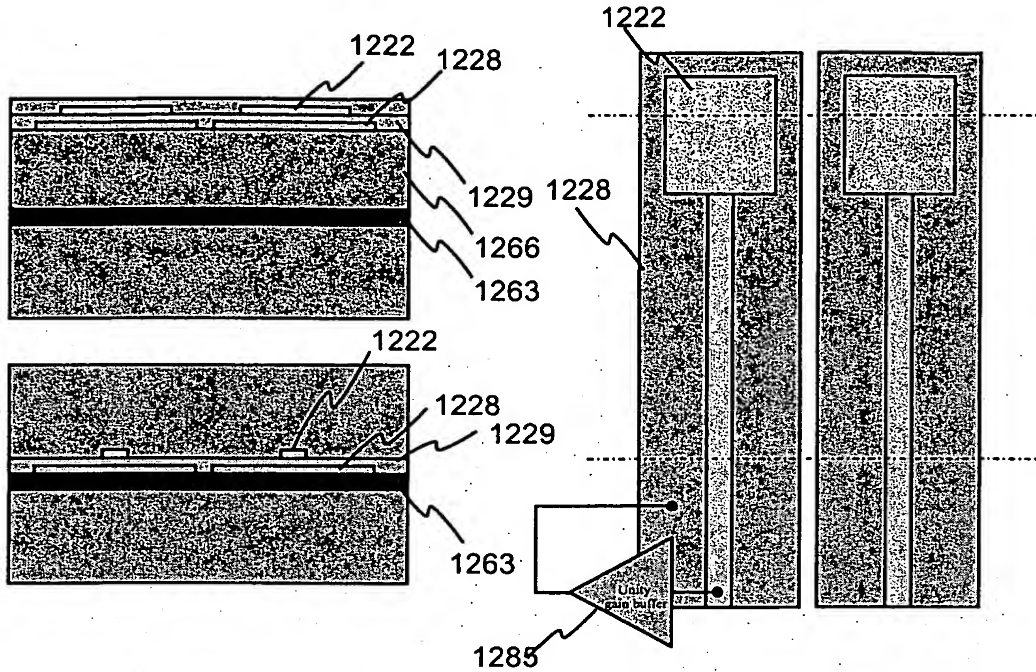

FIG. 12

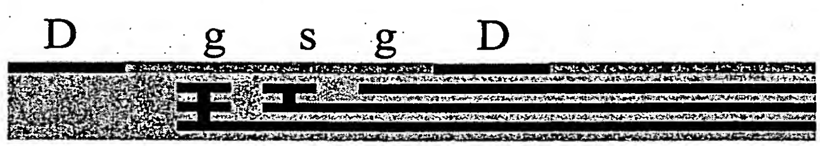

FIG. 13a

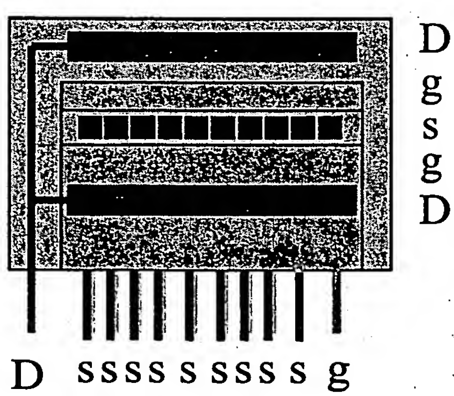

FIG. 13b

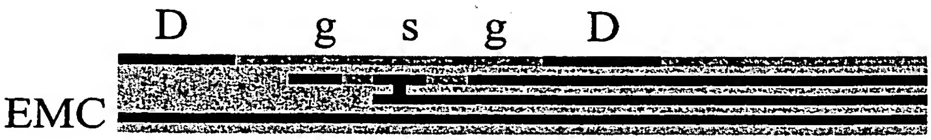

FIG. 14a

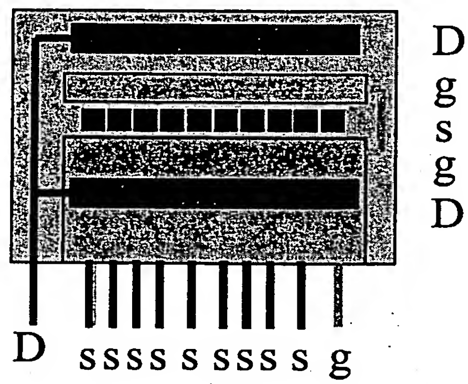

FIG. 14b

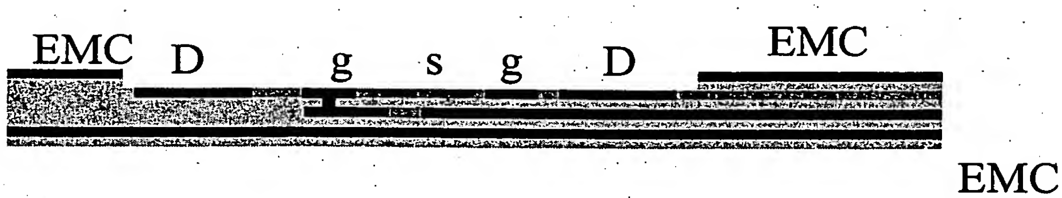

FIG. 15a

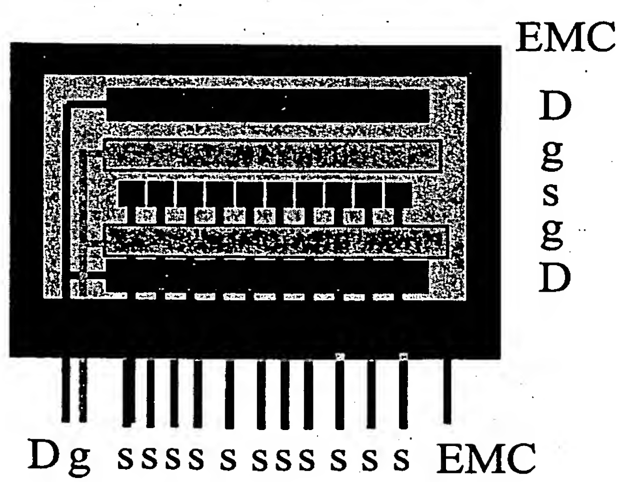

FIG. 15b

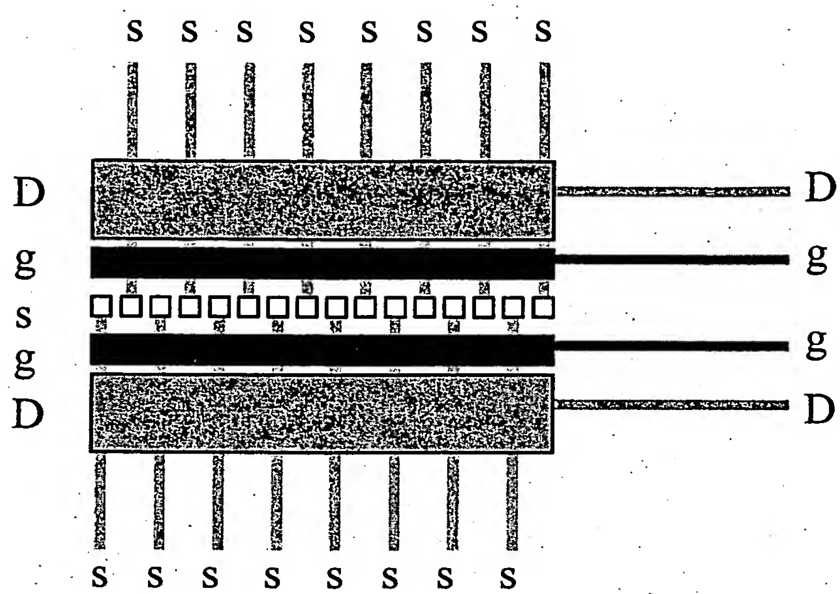

FIG. 16a

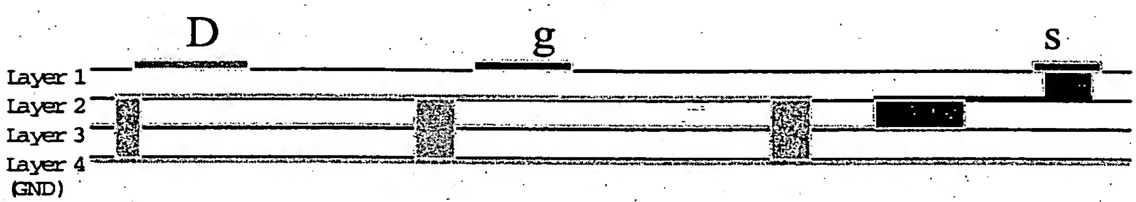

FIG. 16b

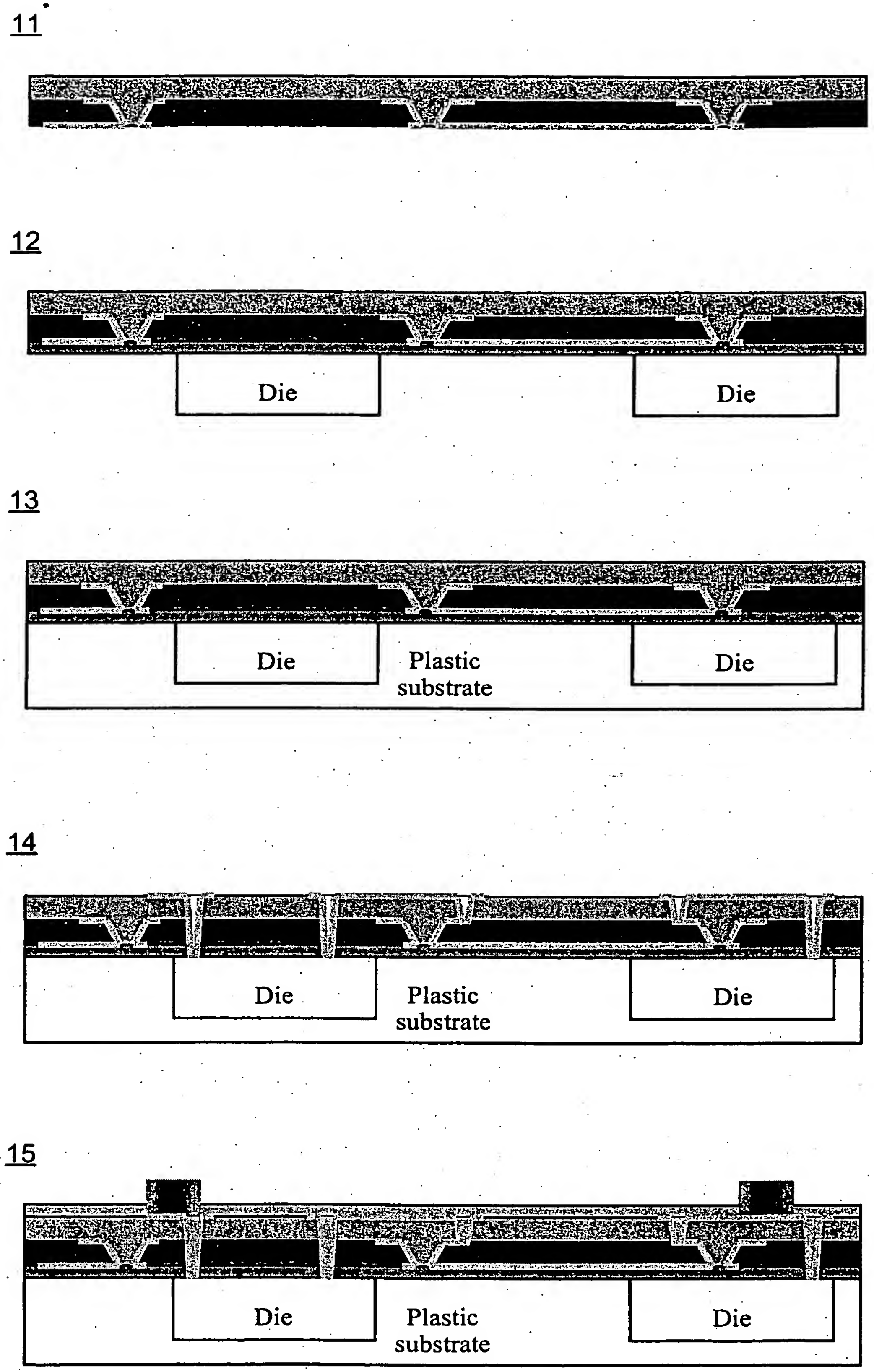
11
12
Die
Die
13
Die
Plastic substrate
Die
14
Die
Plastic substrate
Die
15
Die
Plastic substrate
Die

FIG. 17